

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
4. Concepts						
General	Fitzpatrick			Chapter 4 is comprehensive and well written.	e	Noted
General	Fitzpatrick			The chapter as a whole is generally well written. The conclusions are adequately supported by evidence, it is appropriately balanced, the tone is “impartial and devoid of special pleading”, and none the reports findings are based on value judgments. My specific suggestions for improvements are detailed below. Note that I only read this chapter, not the whole report. Some of my comments may reflect this.	f	Noted
General	Alley			Brief conclusions would be useful (especially when an Introduction is given).	b	Accepted. Synopsis added.
General	Alley			Otherwise does well with covering all the main forcings/feedbacks that matter on these timescales, rules out those that don't, and gives a quick intro to the role proxies play in the science (with most details appropriately left to later chapters where specific applications are discussed). A hint that more details on proxies lie in Ch 5 would help.	b	Accepted. Paragraph added at end of introduction, setting the stage for this and subsequent chapters.
Abstract	Alley	2		The last sentence of the abstract is vague, and could easily be misread. How have the sun, volcanic eruptions and other factors been influential? Influential in what? In recent warming trends observed? Someone might read this as saying that changes in the sun may be a significant cause for the recent observed climate change. Later in the report it says that the changes in the forcing from the sun over time are small compared to recent increases in greenhouse gas concentrations, but the abstract could be read as saying something very different. The authors should be more specific.	f	Accepted. Text changed for clarity.

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Abstract	Fitzpatrick	2	19	As in the prospectus, the use of “sedimentary deposits” here is inappropriate. Note: this reviewer provided the following comment on this topic in response to the Prospectus: <i>"This sentence could be misinterpreted to read as though all paleoclimate records are derived from sediment, which is incorrect. I disagree with the use of the term “sediment” to encompass all proxy data, as it can be misleading."</i>	g	Rejected: Use of the term 'sediment' or 'sedimentary deposits' encompasses any medium that records a temporally resolvable climate signal - not just sedimentary deposits, which is the interpretation the reviewer seems to have adopted. This is clearly explained in 4.3.1.
Abstract	Fitzpatrick	2	21	suggest inserting “tree rings” here.	g	Accepted
Abstract	Fitzpatrick	2	28	as in the prospectus, the use of “sedimentary deposits” here is inappropriate	g	See Note above
4.2.1	Alley	7	134-137	What is a “too-cold” and “too-warm” planet? I get the point, but this may be confusing to a lay person. I would leave these two sentences out.	f	Accepted. Clarification added.
4.2	Alley	5 - 19	85-411	Regarding the different subsections of 4.2, it is not always clear whether the topic being discussed is a forcing, feedback or just an aspect of (natural) variability. This being a somewhat long section, it's important to not lose track that these are the topics being covered here.	b	Noted.
4.4	Alley	26 - 30 30-35	568 - 649 651-766	The flow of ideas would probably be improved if these two sections were swapped. In this way, the history would follow the coverage of chronology and cap the chapter.	b	Rejected. Text optimized to current order.
4.1	Alley	5	77-78	“continental drift”, see Ch 3.	b	Accepted. Reworded.
4.1	Alley	5	81-82	Isn't “developing scientific explanations” also a part of “paleoclimatology”?	b	Accepted. Reworded.
4.2	Alley	6	105	“blocked by that carbon dioxide” is inappropriate. Better terminology needed (as done in 4.2.4 246-249). Also see pg 8, ln 137-140.	b	Accepted. Reworded.

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4.2.1	Alley	7	134-137	Discussion of energy balance is unclear. “Too cold” planets <i>retain</i> more energy rather than <i>receiving</i> it. Description for “too warm” planets seems to get it right. Consider a slightly more detailed treatment including why there’s a balance.	b	Rejected. Text is correct as stated; a planet colder than equilibrium receives more energy than it radiates. The retained energy may be a tiny fraction of the received.
4.2.1	Alley	8	145-146	I would substitute the word “return” for the word “emit”. “Return” suggests that the Earth emits radiation back to where it came from, the sun, when it really emits radiation in all directions into space.	f	Accepted.
4.2.1	Alley	8	153-155	Again, this last sentence is vague. I would reword something like “... may have a small effect but are not as important as the forcings mentioned above.”	f	Accepted. Reworded.
4.2.2a	Alley	9	175	Replace the words “more significant” with “larger”.	f	Accepted. Reworded.
4.2.2b	Alley	10	184	Replace the word “changes” with “variability”.	f	Accepted.
4.2.2b	Alley	10	187	Replace the word “their” with “the”.	f	Removed in rewording.
	Alley	10	195-197	Where is “radiative forcing” introduced? How do the forcings listed compare to the average solar output?	f	Accepted. Introduction now provided.
4.2.4	Alley	13	258-270	This paragraph does not make a wholly compelling argument for why water vapor can be ignored (more or less) as a greenhouse gas. Need to strengthen and clarify.	b	Noted. The text has been clarified. However, the text does not, should not, and cannot make a case that water vapor can be ignored as a greenhouse gas, but only that water vapor is more of a feedback than a forcing.
4.2.4	Alley	13	258-270	Perhaps it would be more explicit to emphasize that water vapor is a feedback, rather than an external forcing (especially since these were defined previously).	f	Accepted. Text reworded.
4.2.4	Alley	12	282-287	This paragraph seems out of place. For example, what is the relationship between climate and greenhouse gases? Why is climate change in the Arctic amplified? These seem to come out of nowhere and are not backed up. Both are important points, but they should be substantiated.	f	Accepted. Text reworded, with reference to more-complete treatment in chapter 5.

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4.2.6	Alley	16	335-341	It is probably not clear to the lay person how volcanic activity is related to continental drift. As such it seems out of place. Perhaps put this into the following section on volcanic eruptions.	f	Accepted. Text added at the end of section 4.42.5 to introduce the concept.
4.2.6	Alley	16	329-341	<i>Some</i> evolution is certainly on the same timescales as continental reorganizations, but is it accurate to prohibit evolutionary change from being significant on millennial (or multimillennial) scales? Bringing the long-term aspects of plate tectonics and evolution together is sensible but current headings blur timescales. There are both long- and short-term aspects to biology but (generally) only long-term aspects to plate tectonics.	b	Noted. MAJOR evolutionary change is referenced.
4.2.7	Alley	18	383	Is this a 1°C global cooling, or just a cooling over Greenland?	f	Noted. Specification is clearly made of Greenland ice-core records, which are described in the text as providing records solely of local climate.
4.2.7	Alley			Could end this paragraph whether or not there is a trend over time in the number or strength of volcanic eruptions.	f	Rejected. This is already included in the previous sentence.
4.2.8	Alley	19	409-411	Don't changes in the sun's output also affect the planet's temperature directly? Isn't the key difference here trends in forcing over time (e.g. there is no trend in explosive volcanic eruptions)? I'm not sure what the point of these last two sentences is	f	Accepted. Wording clarified.
4.3.1	Alley	22	468-469	The following would make more sense. "... reflects glacial (colder – more ice) ... reflects interglacial (warmer – less ice)..."	f	Accepted.
4.3.1	Alley	22	473	Paragraph beginning on line 473. Paragraph seems out of place. Should this be moved up one paragraph?	f	Accepted in part. Text clarified that one example is followed by general issues and then specific mateds.
4.3.1	Alley	21 -22 24	455-460 514-519	Discussion of isotopes is not fully developed until second occurrence. The earlier, oxygen-oriented section is short on the details delivered in the later, carbon-oriented section. Suggest revising former to add details; latter could be modified as well, to avoid repetition.	b	Accepted in part. Text clarified that one example is followed by general issues and then specific mateds.

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4.3.1	Alley	23	482-484	This belongs in the first paragraph of this section.	f	Accepted in part. Text clarified that one example is followed by general issues and then specific mateds.
4.3.2	Alley	25 - 26	541-566	Suggest adding a caveat as to how dating precision declines with age. This is more or less implied in the discussion of annual layer counting but could be more explicitly addressed (especially with the back-reference at line 625).	b	Accepted.
4.3.2	Alley	26	561	The statement in parentheses is not grammatically correct.	f	Accepted in part. Reworded for clarity.
4.2.1	Alley	8	148	Add ref to Serreze et al. 2007: The large-scale *energy budget* of the Arctic. J Geophys Res, 112.	e	Accepted
4.2.2b	Alley	10	191	why just colder summers here, rather than cold on an annual basis	g	Accepted. Text Modified.
4.2.7	Alley	18	371	Perhaps qualify this sentence – that these three eruptions have been studied in detail using climate models, which I think is the point of the paragraph – since other volcanoes (e.g. Tambora) have been studied as well in a general sense and are not mentioned.	g	Accepted -- we added the note about modeling and point out that Tambora is mentioned in Figure 4.5
4.2.7	Fitzpatrick	18	382	The extensive studies on tree rings and volcanism are not even mentioned here. For example: LaMarche, V. & Hirschboeck, K. Frost rings in trees as records of major volcanic eruptions. Nature 307, 121-126 (1984). Briffa, K., Jones, P., Schweingruber, F. & Osborn, T. 1998. Influence of volcanic eruptions on Northern Hemisphere summer temperature over the last 600 years. Nature 393, 450-455 (1998). Salzer, M. & Hughes, M. Bristlecone pine tree rings and volcanic eruptions over the last 5000 yr. Quat. Res. 67, 57-68 (2007). g, R. & Jacoby, G. Northern North American tree-ring evidence for regional temperature changes after major volcanic events. Climatic Change 41, 1-15 (1999).	g	Accepted
4.3.1	Fitzpatrick	21	440	as in the prospectus, the use of “sedimentary deposits” here is inappropriate	g	See note above
	Fitzpatrick		502-504	Tree-ring references needed here: e.g. Cook, E. & Kairiukstis, L. Methods of Dendrochronology (Kluwer, Dordrecht, 1990). Fritts, H. 1976. Tree Rings and Climate. Academic, London.	g	Accepted

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	Alley		530-533	Ditto references just above; also note that interpretation of tree growth variations in tree rings requires understanding of site history; can optimize the signal of interest depending on site selection.	g	Noted.
4.3.1	Fitzpatrick	25	533	'the temperature of the growing season'	e	Accepted
	Alley		549	the nature of tree-ring cross-dating makes it almost uniquely accurate relative to other proxies, with precise annual resolution.	g	Rejected. Ice-core data over centuries are similarly cross-dated and achieve precise annual resolution.
4.3.2	Alley	25-26	541-566	This section seems incomplete. What about dating beyond 40 or 100 ka? I know it's complicated, but perhaps it can be summarized in a separate paragraph. It seems suspiciously absent.	f	Accepted. Text modified.
4.4	Alley	27	582-588	Replace "has been" with "was".	f	Accepted.
4.4	Alley	29	633-634	I don't know what this sentence means.	f	Accepted. Reworded.
4.4	Alley		General	All of these different timescales may be confusing to a lay person. A figure may help. Perhaps start with Figure 4.9, then "blow up" the last 3 ma, then the last 0.9 ma, then the last 10 ka.	f	Rejected. Preparation of a figure that worked proved impractical.
4.5	Alley	31	680	'and in north-central Labrador until about 6,000 years ago.'	e	Accepted.
4.5	Alley	35	General	The ending seems very abrupt. Maybe it is appropriate in the context of the larger report, which I did not read. But as a stand alone chapter it at least needs a conclusions section	f	Accepted. Synopsis added.
	Alley	9	174-177	which is estimated to have had the same warming effect globally as an increase in solar output (there is still no good way to estimate the effect of changes in the solar irradiance!) of 0.5% (Forster et al., 2007) and thus is more significant than solar irradiance changes over this time (see the previous comment – v.p.)	c	Noted.
	Alley	10	198-199	as high as 0.6 Watts per m ² , still well below (what is "radiative forcing" of the Milankovitch cycles?) the estimated radiative forcing of increased greenhouse gases of the past century (~1.7	c	Noted. This is described in next section.
	Alley	22	462	isotopes oxygen-16 to oxygen-18 (not vise verse?) in seawater	c	Relative abundance can be expressed either way.

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	Alley	30	647-648	The “shape” of the climate records is interesting, with northern records typically showing abrupt warming, gradual cooling, abrupt cooling, near-stability or slight gradual warming, and then repeating (this discussion is not clear. A good figure can help here).	c	Accepted in part. Figure call added.
	Alley	30	654	These include broad warming and then cooling over millennia, abrupt events probably linked to the older abrupt changes????, and additional events with various spacings and sizes????? that have a range of causes, which will be described more in chapters 5 and 6 (The same comment as for the previous paragraph).	c	Accepted in part. See note in previous comment.
4.2.2b	Alley	10	196-199	with the estimated minimum level of at least 0.2 Watts per m ² , and some estimates as high as 0.6 Watts per m ² , still well below the estimated radiative forcing of increased greenhouse gases of the past century (~1.7 Watts per m ²) (IPCC, 2007). The radiative forcing range of uncertainty is large (~ ±1 W/m ²) and should be given here since the lower end of the error bar is around 0.7 W/m ² . The uncertainty is due mostly to our lack of understanding of the aerosol effect (IPCC 2007, FAQ 2.1, Fig 2.). Also, the source of the “as high as 0.6 W/m ² ” estimate should be singled	d	Accepted in part. Text has been clarified. Text notes radiative forcing of greenhouse gases, not total anthropogenic radiative forcing including aerosols, etc.
4.2.2b	Alley	14	282	The direct relationship between climate change and greenhouse gases such as CO ₂ and methane is clearly described by the recent IPCC report (IPCC, 2007). Both the pattern of observed warming in the direct observational record, especially the record of the past 30 years, as well as climate model simulations (needs definition or short description of climate models), suggest that the Arctic will be more impacted by increases in greenhouse gas concentrations than any other region on Earth (Figure 4.4).	d	Accepted in part. Text modified.

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4.4	Alley	29	621	<p>Please add Clark et al 2006</p> <p>Clark, P.U., D. Archer, D. Pollard, J. Blum, J.A. d, V. Brovkin, A. Mix, N.G. Piasias, and M. Roy (2006): The Middle Pleistocene Transition: Characteristics, Mechanisms, and Implications for Long-term Changes in Atmospheric pCO₂, Quaternary Science Reviews, Special Issue in honor of Nick Shackleton ; 25, pp. 3150-3184</p> <p>A brief discussion of the ‘much research’ involved here is important. The reader is now intrigued that the Milakovitch periodicities do appear in the record, but the narrative has not yet offered a comforting explanation or some of the possibilities the research over the last 30 years has produced.</p>	d	Accepted in part. Reference added. Discussion of research pathways is beyond the scope of the chapter.
4.5	Alley	35	746	It should be clearly noted that tuning can in fact destroy important information about the nature of the forcing and the nature of the climate system response. It should also be noted that relying on tuning is tantamount to assuming that the climate system response is proportionate (linearly related) to the input, which is probably a pretty bad assumption, given all that has been said previously about the complexity of the climate system.	d	Accepted. Text modified.
	Alley	35	756	Recognizing that there are probably faulty assumptions inherent in the use of the.....	d	Accepted. Text modified.
	Alley	35	756-766	Please explain the origin and need at this time of the MIS nomenclature. Also, the above rationale to support using SPECMAP is weak and for a non-specialist sounds inconsequential.	d	Rejected. Some nomenclature is needed, and this one is widely Accepted. The reader can judge the strength of the reasoning.
Figure 4.5	Fitzpatrick			Average deposition of what? What are the units?	f	No change necessary: Caption states that it is the distribution of volcanic sulfate aerosols in kg/km² referred to in the figure.
Figure 4.6.	Fitzpatrick			This does not show the isotopic record as the caption implies. It is derived from the isotopic record though.	f	Accepted. Caption re-written to clarify.

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4.2.2	Alley			section 4.2.2: note that more recent estimates are all on the low end. In particular the logic that supported 0.6 W/m2 at the Maunder Minimum has evaporated in the light of newer information.	i	Accepted.
4.2.3	Alley			section 4.2.3: (out-of-roundness) => (departure from circularity)	i	Accepted.
4.2.4	Alley			section 4.2.4: 33 deg C warmer is 59.4 deg F warmer, not 57 deg F.	i	Accepted.
4.2.7	Alley			section: 4.2.7: tropical eruptions interact with the Brewer Dobson circulation to produce a longer timescale response than high latitude eruptions. Cite Shindell et al (2004, JGR) and Fischer et al (2007) on the dynamical response to large tropical volcanoes in recent centuries	i	Accepted in part. (Brewer Dobson circulation a bit technical for this section, so omitted.)
4.2.8	Alley			section 4.2.8: "the climate did not track the beryllium-10" - unclear, rephrase to state that there was no related climate response.	i	Accepted. Wording changed.
	Alley			trained historians - remove qualifier - it's patronising	i	Accepted.
4.3.1	Alley			section 4.3.1: "Climates Proxies" => Climate Proxies Neither tree-rings nor pack rat middens are 'sediments' in any sense of the word, and even stalagmites are a stretch. Please reconsider this framing.	i	Rejected. The text notes that sediment is "broadly defined" here. We have not found a single label that is more useful than "sediment" for the purposes here.
4.3.1	Alley			4,3,2: "other times with less precision." => other examples with less precision "the damage that accumulates from cosmic rays" - increased 10Be on an exposed rock can't really be described as 'damage'. Use 'effect'.	i	Accepted. Wording changed.
4.4	Alley			4.4: "rapid decreases in foraminifera 18O at about 34 Ma ago..." The previous sentence seems to imply this was a time of warming - some confusion here. "decades to years" - drop 'years' - this is not replicatable across ice cores nor does it make sense in a noisy series	i	Accepted. Text changed.
	Alley			All text and captions: W/m2 is the standard unit description for climatically relevant energy fluxes over the Earth. Please use this consistently.	i	Noted. Changes made as appropriate.

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General	Alley			ch 4 The chapter title should be "climate concepts" because it is not only about paleoclimate. The first exclusively paleoclimate concept doesn't appear until page 11. The abstract is not representative of the generality of much of the chapter.	j	Accepted in part. Abstract has been reworded somewhat. Title of chapter maintained.
General	Alley			ch 4 I don't think this chapter is a good idea overall. It is too long and abstract to hold the attention of the nonscientists. I think the information would be more useful if distributed as introductions and in text boxes throughout the other chapters. In addition, the material could be tightened and made less flowery, and more references are needed.	j	Noted. Additional extensive referencing is provided in chapters 5-8, and a pointer to the material in those chapters has been added.
	Alley		87-88	line 87-88 the first and third categories are not separable - in contradiction with the sentence wording. The section text correctly indicates their connection.	j	Accepted. Reworded for clarity.
	Alley		104-105	line 104-105 change to "from those volcanoes in a couple of years following an eruption, and the Earth's surface will be warmer on average in response."	j	Rejected. The sentence refers to the number of eruptions per century, not the output of ash per eruption.
	Alley		185	line 185 I don't think it is necessary or true to call the 11-yr solar induced climate change small. It has been argued that global warming in the past 5 years has eased owing to the 11 yr solar cycle. It would be better to emphasize the difference in forcing on timescales. The 11-yr solar cycle can compete with anthropogenic climate change on decadal timescales, but not on century timescales.	j	Accepted. Numerical values added rather than qualitative terminology.
	Alley		189	line 189 Be specific here and indicate that the solar variability may have contributed only weakly to long-term (near century-scale) temperature trends early in the 20th century. Presently the time-scale of the variability is not mentioned.	j	Accepted. Reworded.
	Alley		193-194	line 193-4 A reference is needed for these longer solar cycles. I have never heard of them and doubt their significance.	j	Accepted. Reference to Frohlich and Lean (2004) added.
	Alley		276	line 276 What focus? Do you mean with regard to anthropogenic GHG emissions? The statement is not true for many times in the past.	j	Accepted. Reworded for clarity.
	Alley		281	line 281 Assessment is misspelled.	j	Accepted.
	Alley		329	line 329 decompose should be combust, I think	j	Accepted. Changed.
	Alley		402	line 402 this section title should be improved	j	Accepted. Title changed.

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	Alley		405	line 405 what does "it" refer to?	j	Accepted. Reworded for clarity.
	Alley			line 610-611 presumably it is meant that methane is released from ocean sediments, not the ocean.	j	Accepted. Wording changed.